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РОССИЙСКОЕ АГЕНТСТВО
ПО ПАТЕНТАМ И ТОВАРНЫМ ЗНАКАМ

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к патенту Российской Федерации

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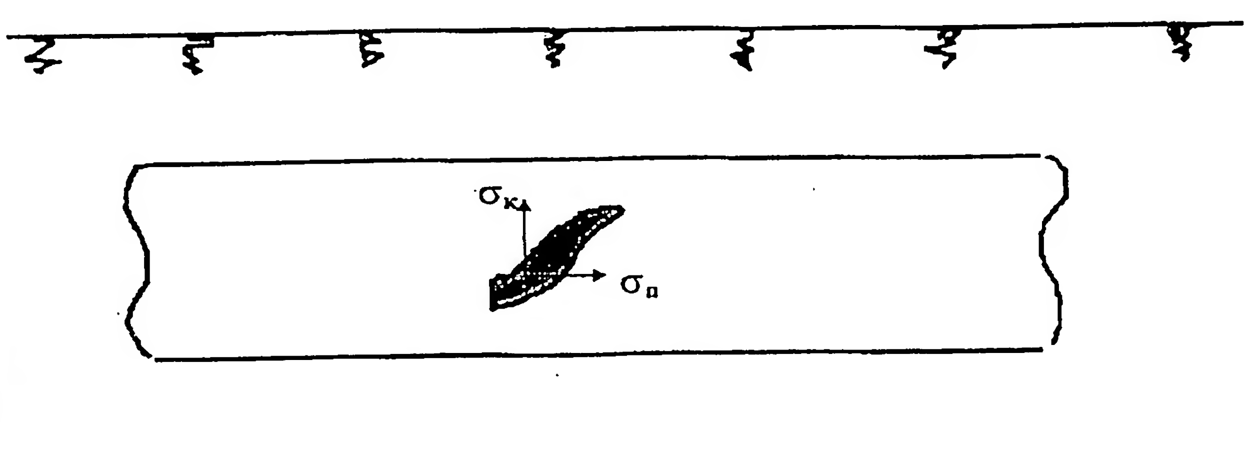
(72) Гончаров Н.Г., Гобарев Л.А., Лопатин Е.В., Романова И.А., Сабиров У.Н., Кенегесов Ю.Т., Шишко В.А., Горицкий В.Н.
(71) (73) Общество с ограниченной ответственностью "ВНИИСТ-СКТ"
(56) Инструкция по ремонту трубопроводов и резервуаров с помощью полимерных клеевых композиций, РД-39-30-968-83. - М.: Миннефтегазстрой, М., 1984, с. 18-19. RU 2097646 C1, 27.11.1997. SU 1451422 A1, 15.01.1989. WO 094/00211 A, 22.12.1994.
(98) 105187, Москва, Окружной проезд 19, ком.320, ООО "ВНИИСТ-СКТ", Гончарову Н.Г.

(54) СПОСОБ РЕМОНТА МЕТАЛЛИЧЕСКИХ ТРУБОПРОВОДОВ (ВАРИАНТЫ)

(57) Изобретение относится к области строительства и ремонта трубопроводов и может быть использовано при ремонте и реконструкции резервуаров, котлов и сосудов высокого давления. Способ ремонта металлических трубопроводов, имеющих дефектные области, заключается в наложении муфт. При сниженном давлении в трубопроводе осуществляют механическую очистку от изоляционного покрытия и ржавчины поверхности трубы, обезжиривание, нанесение преобразователя ржавчины распылением, наложение ленты под натяжением с последующей фиксацией муфты на трубопроводе, при этом производят нагрев поверхности трубы, выравнивают поверхность высокопрочной мастикой. При ремонте кольцевых швов или близколежащих дефектов накладывают три муфты, каждая шириной не менее 100 мм, вначале накладывают боковые муфты на расстоянии не более 5 мм с каждой стороны сварного шва или близколежащих дефектов, пространство между боковыми



Фиг. 1.

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Установлено, что снижение кольцевых напряжений в несущей трубе будет зависеть от относительного уменьшения давления в момент установки муфты и относительной толщины стенки муфты следующим образом:

$$\sigma/\sigma_0 = P_y/P_0+(1-P_y/P_0)/(1+\delta_м/\delta), \quad (1)$$

где σ - кольцевые напряжения растяжения в стенке трубы под установленной муфтой при рабочем давлении P_0;

σ_0 - кольцевые напряжения растяжения в стенке трубы без муфты при рабочем давлении P_0;

P_y - давление в трубопроводе при установке муфты;

P_0 - рабочее давление в трубопроводе;

$\delta_м$ - толщина стенки муфты;

δ - толщина стенки трубы.

На фиг. 2 графически показана зависимость (1) относительного снижения напряженного состояния стенки трубопровода (σ/σ_0) под муфтой от степени снижения давления при установке муфты (P_y/P_0) и от ее относительной толщины ($\delta_м/\delta$).

Как видно из графика, зона оптимального снижения давления в стенке трубопровода P_y находится в диапазоне 50-70% от P_0. При этом максимальный уровень давления ограничен возможностью разрыва трубопровода, имеющего дефекты, а минимальный уровень давления ограничен условиями производительности (т.е. при более низком давлении может произойти остановка бесперебойного транспорта продукта).

Технической задачей изобретения является разработка способа ремонта трубопровода с помощью композитных муфт, которые воспринимали бы кольцевые и продольные напряжения на ремонтируемом участке трубопровода, а также предотвращали развитие коррозионных процессов в зоне ремонта.

Подземный действующий трубопровод представляет собой "бесконечную" цилиндрическую оболочку, "равномерно" защемленную грунтом и нагруженную внутренним давлением (фиг. 1).

Продольные напряжения $\sigma_п$ в металле такой оболочки (в подземном трубопроводе) в общем случае составляют μ = 0,28 (коэффициент Пуассона для упругой области деформирования) от кольцевых напряжений $\sigma_к$:

$$\sigma_п= \mu\cdot\sigma_к= 0{,}28\sigma_к.$$

Учитывая, что на линейных участках трубопровода кольцевые напряжения составляют приблизительно 0,72 от нормативного предела текучести $\sigma_{т(норм)}$, продольное напряжение $\sigma_п$ в общем случае можно представить:

$$\sigma_п= 0{,}28\cdot 0{,}72\sigma_{т(норм)}= 0{,}28\sigma_{т(норм)}.$$

Для труб большого диаметра из стали класса прочности К60 $\sigma_{т(норм)} \geq$ 461 МПа или API (X70) $\sigma_{т(норм)} \geq$ 482 МПа продольные напряжения в общем случае составят:

$$\sigma_п= 0{,}2\cdot(461\text{-}482) \approx 100\ \text{МПа} \approx 10\ \text{кгс/мм}^2.$$

Предложенный подход позволяет устранить продольные напряжения, зависящие от многих факторов и изменяющиеся во времени при эксплуатации, в частности от разницы температур эксплуатации и так называемой "температуры замыкания при строительстве", а также от различных изгибающих нагрузок, при этом ремонтная муфта будет воспринимать не только кольцевые, но и продольные напряжения, возникающие на ремонтируемом участке трубопровода.

Поставленная задача достигается за счет установки на ремонтируемый участок герметичной полноохватывающей муфты из композитных материалов с заданной толщиной стенки при заданном снижении давления в трубопроводе или при определенных условиях обжатия трубы муфтой при отсутствии давления в трубопроводе.

Предлагаемая муфта воспринимает нагрузки в продольном и поперечном направлении и состоит из комплекта основных композиционных материалов и вспомогательных компонентов (преобразователь ржавчины, грунтовка, мастика для восстановления геометрии трубы, композиционная высокопрочная лента на тканевой основе, клеящий материал для склеивания витков ленты между собой и приклеивания муфты к металлу трубы). В процессе нанесения указанных компонентов на трубу при условии выполнения нижепредложенных технологических операций, образуется монолит в виде муфты со сложной структурой, которая обладает оптимальными физическими, прочностными и антикоррозионными свойствами.

4.4. Промышленная применимость с примерами реализации.

Способ ремонта включает в себя выполнение комплекса технологических операций в строго определенной последовательности.

С помощью известных физических методов и приборов (механические деформоменты, стресс-сканы, рентгеновские дифрактометры, лазерные интерферометры) определяются напряжения на ремонтируемом участке в дефектной области.

По формуле (1) рассчитывается уровень снижения рабочего давления в трубопроводе,

(Блистеринг, "H1C" по NACE TM 0284-87, последняя редакция) и имеет пороговые напряжения на уровне 90% от предела текучести материала муфты в стандартном сероводородном растворе (методика NACE TM 01-77-90).

Предложенный способ ремонта металлических трубопроводов может быть реализован при использовании современных композитных материалов, выпускаемых отечественной промышленностью.

В качестве муфтообразующей ленты может быть использована стеклопластиковая лента КСЛ по ТУ 92-115-14-98, которая изготавливается для труб диаметром 219-1420 мм.

В качестве клеев могут быть использованы клеевые составы УП-5-177 по ТУ 6-05-241-31-44, СКН-30-ЭЛ/АФ по ТУ 38.403824-95, ТУ 6-05-16-63-74 и др.

В качестве высокопрочного быстротвердеющего вещества на полимерной основе (мастики) может быть использован материал СКН-30-ЭЛ по ТУ 38.403824-95 (наполнитель) в сочетании с отвердителем АФ-2 по ТУ 6-05-1663-74.

В качестве материалов для холодной "сварки" целесообразно использовать материалы системы "холодной сварки" типа Дурметалл "Пластметалл" по ТУ ХС-01.001; Е+С МеКаТеК 1,2,3,8,10,12; Е+С МеКаТеК ЭКС-ПРЕСС фирмы Кастолин; Tech Sheet L1507 Metall-Tech XRC фирмы Thortex.

Указанные материалы коррозионно-пассивны, их можно использовать в диапазоне температур от минус 30 до плюс 100°С, они обладают высокой вибро- и ударостойкостью. Материалы обладают широкими возможностями модифицирования. При добавке модификатора указанные материалы можно использовать при ремонте трубопроводов, имеющих влажную поверхность, возможен ремонт под водой.

Способ ремонта трубопроводов был опробован в условиях полигона; результаты испытаний - положительные (см. таблицу).

Предложенный способ ремонта металлических трубопроводов прошел успешное опытно-промышленное опробование на объектах ОАО "Газпром" на предприятии "Волготрансгаз", "Волгоградтрансгаз", "Севергазпром", "Пермьтрансгаз".

ФОРМУЛА ИЗОБРЕТЕНИЯ

1. Способ ремонта металлических трубопроводов, имеющих дефектные области, наложением муфт, *отличающийся* тем, что при ремонте кольцевых швов или близколежащих дефектов накладывают три муфты, каждая шириной не менее 100 мм, вначале накладывают боковые муфты на расстоянии не более 5 мм с каждой стороны сварного шва или близколежащих дефектов, пространство между боковыми муфтами заполняют самотвердеющим формообразующим веществом или рулонной лентой из стеклоткани, пропитанной клеевым составом, после отверждения которых накладывают верхнюю центральную муфту с равным удалением ее краев от центра шва или кольцевой оси близколежащих дефектов.

2. Способ ремонта металлических трубопроводов, имеющих дефектные области, наложением муфт, *отличающийся* тем, что при восстановлении несущей способности трубопровода на протяженном участке осуществляют наложение муфт шаговым способом с установкой их последовательно друг за другом на расстоянии не менее 200 мм и не более одного диаметра ремонтируемой трубы.

3. Способ ремонта металлических трубопроводов, включающий снижение давления в трубопроводе, механическую очистку от изоляционного покрытия и ржавчины поверхности трубы, обезжиривание, нанесение преобразователя ржавчины распылением, наложение ленты под натяжением с образованием муфты и последующей фиксацией муфты на трубопроводе, *отличающийся* тем, что устанавливают пониженное давление в трубопроводе из соотношения:

$$\sigma = \{P_y/P_o+(1-P_y/P_o)/(1+\delta_м/\delta)\}\sigma_o,$$

где σ - кольцевые напряжения в трубе под установленной муфтой при рабочем давлении P_o;

σ_o - кольцевые напряжения в трубе без муфты при рабочем давлении P_0;

P_y - давление в трубопроводе при установке муфты;

P_0 - рабочее давление в трубопроводе;

$\delta_м$ - толщина стенки муфты;

δ - толщина стенки муфты,

производят нагрев поверхности трубы, выравнивают поверхность формообразующим веществом и осуществляют наложение ленты с толщиной стеклопластиковой муфты, равной

$$\delta_м \geq 1{,}15D\delta/[(\sigma_{bc}/\sigma_b)(D-\delta)-1{,}15\delta],$$

где D - наружный диаметр трубы;

σ_{bc} - нормативное временное сопротивление разрыву композитного материала муфты в кольцевом направлении;

σ_b - нормативное временное сопротивление разрыву металла трубы,

длина стеклопластиковой муфты равна

$$L_c \geq L_d + 3{,}12(R_\delta)^{1/2},$$

где L_d - длина дефекта;

$R_\delta = (D-\delta)/2$ - радиус срединной поверхности трубы,

при этом ленту перед ее намоткой пропитывают клеевым составом или выполняют самоклеящейся.

4. Способ по п.3, *отличающийся* тем, что нагрев осуществляют в пределах от 15°С до максимального значения, определяемого физико-химическими свойствами компонентов.

5. Способ по п.3, *отличающийся* тем, что наложение муфты осуществляют с предварительным нанесением на трубу быстротвердеющего формообразующего вещества, наматывают рулонную ленту, состоящую из многослойной стеклокомпозиционной ткани с расположением нитей в продольном и поперечном направлении на формообразующее вещество, находящееся в отвержденном недеформируемом состоянии, при этом все слои ленты, включая место контакта поверхности трубы с первым витком ленты, последовательно проклеивают непрерывным слоем клея в процессе ее намотки, которую осуществляют плотным прилеганием слоев с контролируемой величиной натяжения при помощи натягивающего устройства с динамометром, после чего конец ленты нежестко позиционируют с помощью эластичного фиксатора и производят термообработку муфты до отверждения клеевого состава и набора им конструктивной прочности.

6. Способ по п.3, *отличающийся* тем, что в случае наличия в трубе трещин или сквозных дефектов ремонт проводят с применением метода "холодной сварки".

7. Способ по п.3, *отличающийся* тем, что рулонную ленту изготавливают в "самоклеящемся" исполнении, с предварительно нанесенным слоем клея на одну сторону ленты.

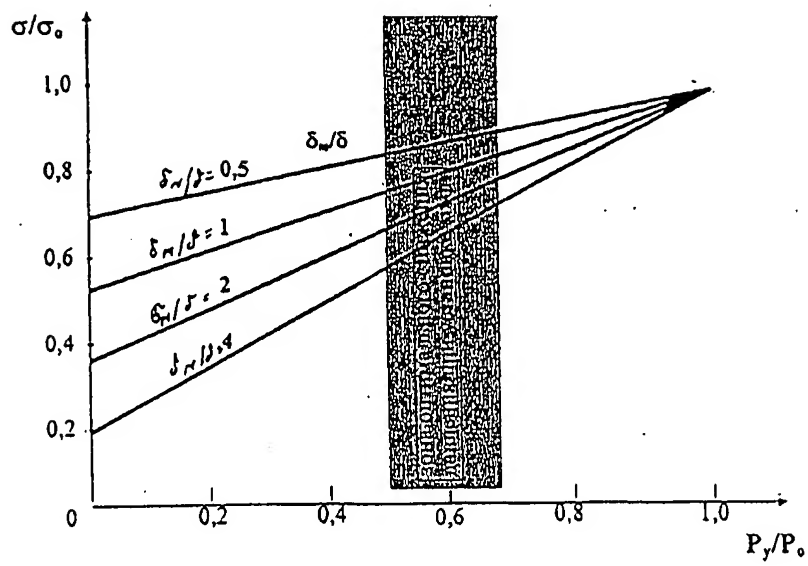
8. Способ по п.3, *отличающийся* тем, что на дефектное место (коррозионные язвы, вмятины и т.д.) наносят высокопрочное быстротвердеющее вещество на полимерной основе, после его отверждения излишний слой удаляют до высоты 0,5 - 0,8 мм над поверхностью трубы, после чего производят намотку ленты, намотку ленты осуществляют ручным или механизированным способом с контролируемой величиной натяжения, при этом сила натяжения не должна превышать массы рулона, контроль величины натяжения осуществляют динамометром и рассчитывают по формуле

$$F = F_0 \cdot e^f,$$

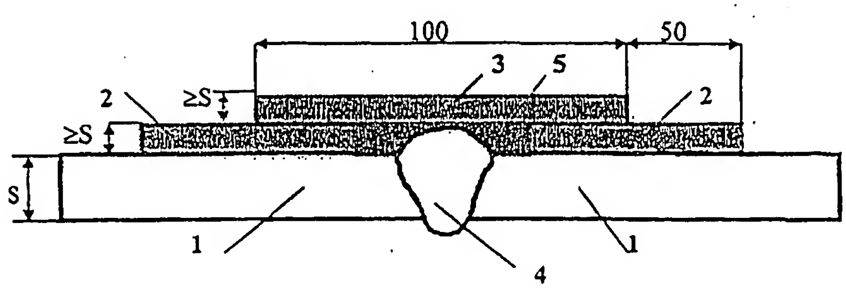
где F_0 - сила натяжения материала ленты у начального ее контакта с поверхностью трубы;

f - коэффициент трения проклеенного последующего витка ленты о поверхность предыдущего витка.

9. Способ по п.3, *отличающийся* тем, что при помощи формообразующего вещества кривизну трубы в зоне наложения муфты выравнивают до уровня не более 0,5 мм на длине 300 мм.


σ/σₒ
1,0
0,8
0,6
0,4
0,2
0
0,2
0,4
0,6
0,8
1,0
P_y/P_o
δм/δ
δм/δ= 0,5
δм/δ = 1
δм/δ = 2
δм/δ=4

Фиг. 2.


100
50
3
5
2
2
≥S
≥S
S
1
1
4

Фиг. 3.

(21) 99110629 / 06 (22) 19.05.1999
(24) 19.05.1999
(46) 10.09.2000 Bull. No. 25
(72) Goncharov N.G., Gobarev L.A., Lopatin E.V., Romanova I.A., Sabirov U.N., Kenegesov Yu.T., Shishko V.A., Goritsky V.N.
(71) (73) Limited Liability Company "VNIIST-SKT"
(56) Instruction for the repair of pipelines and reservoirs with the aid of polymer adhesive compositions, PD-39-30-968-83. RU 2097646 C1, 27.11.1997. SU 1451422 A1, 15.01.1989. WO 094/00211 A, 22.12.1994.
(98) 105187 Moscow, Okruzhnoi lane 19, room 320, LLC "VNIIST-SKT", Goncharov N.G.
(54) METHOD OF REPAIR OF METAL PIPELINES (VERSIONS)
(57) The invention is related to the field of construction and repair of pipelines and may be used in the repair and reconstruction of reservoirs, boilers and high-pressure vessels. The method of repair of metal pipelines which have defected areas consists in applying couplings. At a reduced pressure in a pipeline efforts are made for mechanical cleaning from insulating coat and rust of pipe surface, degreasing, application of rust penetrating solvent by spraying, applying a tape under stress with a subsequent coupling fixation on the pipeline, in this case the pipe surface is heated, the surface is leveled by a high-strong mastic. When repairing annular seams or nearby defects, three couplings are applied, each one no less than 100 mm wide, at first side couplings are applied at a distance not exceeding 5 mm at each side of a weld or nearby defects, the space between side ....

It has been established that reduction of hoop stresses in a supporting pipe will depend of the relative decrease of pressure at the moment of coupling installation and relative coupling wall thickness in the way as follows:

$$\sigma/\sigma_o = P_{inst} / P_0 + (1 - P_{inst} / P_0) / (1 + \delta_M/\delta), \qquad (1)$$

where σ – hoop stresses of tension on the pipe wall under the installed coupling at the operating pressure P_0;

σ_o - hoop stresses of tension in the pipe wall without coupling at the operating pressure P_0;

P_{inst} - pressure in the pipeline during coupling installation;

P_0- operating pressure in the pipeline;

δ_M - thickness of coupling wall;

δ- thickness of pipe wall.

Figure 2 shows graphically the relation (1) between the relative decrease of pipeline wall stressed state (σ/σ_o) under the coupling and the degree of pressure decrease during the installation of coupling (P_{inst} / P_0) and its relative thickness (δ_M/δ).

As is seen from the diagram, the zone of optimum pressure decrease in the pipeline wall is within the range of 50 to 70% of P_0. In this case the maximum pressure level is restricted by a probability of pipeline rupture and the minimum pressure level is limited by efficiency conditions (i.e. at lower pressure stoppage of faultless transportation of product may occur).

The technical task of the invention is the development of pipeline repair method with the aid of composite couplings that would take hoop and longitudinal stresses on a pipeline repair section, and also would prevent the development of corrosion processes in the repair zone.

An underground operating pipeline is essentially an "endless" cylindrical enclosure that is "uniformly" pinched by ground and loaded with internal pressure (Fig. 1).

Longitudinal stresses σ_l in the metal of such an enclosure (in an underground pipeline) in a common case amount to $\mu = 0.28$ (Poisson coefficient for the elastic field of strain) of hoop stresses σ_h:

$$\sigma_l = \mu \cdot \sigma_h = 0.28\,\sigma_h.$$

Considering that hoop stresses on linear sections of the pipeline amount approximately to 0.72 of the rated yield point $\sigma_{l\,(rated)}$, the longitudinal stress σ_l in the common case can be presented as:

$$\sigma_l = 0.28 \cdot 0.72\,\sigma_{l\,(rated)} = 0.28\sigma_{l\,(rated)}.$$

For pipes of the large diameter made of steel of strength class K60 $\sigma_{l\,(rated)} \geq 461$ MPa or API (X70) $\sigma_{l\,(rated)} \geq 482$ MPa longitudinal stresses in the common case will amount to:

$$\sigma_l = 0.2 \cdot (461\text{-}482) \approx 100 \text{ MPa} \approx 10 \text{ kgf/mm}^2.$$

The proposed approach makes it possible to eliminate longitudinal stresses that depend on many factors and change in time when operated, in particular, on operation temperature differences and on the so-called "closing temperature at construction", as well as on various bending loads, in this case the repair coupling will take not only hoop stresses but longitudinal stresses as well that arise on the pipeline repair section.

The set task is solved at the expense of installing a tight fully-embracing coupling made of composite materials on the repair section with a preset wall thickness at a preset decrease of pressure in the pipeline or under certain conditions of pipe clamping by the coupling, when there is no pressure in the pipeline.

The proposed coupling takes loads in longitudinal and transverse directions and consists of a set of main composite materials and auxiliary components (rust penetrating solvent, primer, mastic for recovering pipe geometry, composite high-strength fabric-backed tape, adhesive for bonding the turns of tape between each other and for bonding the coupling to pipe metal). In the course of applying the said components on the pipe and providing the observance of process operations proposed below a monolith is created in the form of a coupling with a complicated structure that features optimal physical, strength and corrosion-resisting characteristics.

4.4. Industrial applicability with the examples of realization.

The method of repair comprises the implementation of a set of process operations in a strictly determined succession.

With the aid of known physical methods and instruments (mechanical dynamometers, stress-scanners, X-ray diffractometers, laser interferometers) stresses on the repair section in the defected field are determined.

According to formula (1) the level of decreasing the working pressure in the pipeline is calculated, ...

(Blistering, "H1C" according to NACE TM 0284-87, latest wording) and has threshold stresses at the level of 90% of the yield point of coupling material in a standard hydrosulfuric solution (NACE methods TM 01-77-90).

The proposed method of repairing metal pipelines can be realized with the use of updated composite materials manufactured by domestic industry.

Tape of glass-reinforced plastic KSL according to TU 92-115-14-98 which is manufactured for pipes of 219-1420 mm in diameter, may be used as a tape that forms a coupling.

Adhesives used for this purpose may include glue compositions like UP-5-177 according to TU 6-05-241—31-44, SKN-30-EL/AF according to TU38.403824-95, TU 6-05-16-63-74 and others.

For high-strength rapid-setting polymer-based substance (mastic) use may be made of material SKN-30-EL according to TU38.403824-95 (filler) combined with curing agent AF-2 according to TU 6-05-1663-74.

For materials used for cold "welding" it is recommended to use materials of "cold welding" system of type Durmetall "Plastmetall" according to TU HS-01.001; E+C MeKaTek 1,2,3,8,10,12; E+C MeKaTek EKS-PRESS, firm Kastolin; Tech Sheet L1507 Metall Tech XRC, firm Thortex.

The said materials are corrosion-passive, they may be used within the temperature range from minus 30 to +100°C, they feature high vibro- and impact stability. The materials offer wide possibilities for modifying. With a modifying agent added the said materials may be used in the repair of pipelines with wet surfaces, repair under water is also possible.

The method of pipeline repair was tested in field conditions, test results are positive (see the Table).

The proposed method for repairing metal pipelines has passed successful experimental-industrial testing at objects of PJSC "Gazprom" including enterprises "Volgotransgaz", "Volgogradtransgaz", "Severgazprom", "Permtransgaz".

CLAIMS

1. A method of repairing metal pipelines having defective areas by applying couplings **characterized in** that during the repair of annular seams or nearby defects, the space between the side couplings if filled with self-setting shape-generating material or rolled tape made of glass cloth impregnated with adhesive; after setting of these latter the upper central coupling is applied, its edges located at equal distances from the weld center or annular axis of nearby defects.

2. A method of repairing metal pipelines having defective areas by applying couplings **characterized in** that during the recovery of pipeline bearing capacity on a long section application of couplings is realized in a step-by-step method, when they are installed at a distance not less than 200 mm one after another and not in excess of one diameter of a pipe repaired.

3. A method of repairing metal pipelines including the decrease of pressure in a pipeline, mechanical cleaning of the pipe surface from insulating coat and rust, degreasing, application of rust penetrating solvent by spraying, applying the tape under tension with the formation of a coupling and subsequent coupling fixation on the pipeline, **characterized in** that a reduced pressure in the pipeline is established on the basis of the following ratio:

$$\sigma = \{P_{inst} / P_0 + (1 - P_{inst} / P_0) / (1 + \delta_M/\delta)\}\, \sigma_0,$$

where σ – annular stresses in the pipe under the installed coupling with the working pressure P_0;

σ_0 – annular stresses in the pipe without coupling with the working pressure P_0;

P_{inst} - pressure in the pipeline, when installing the coupling;

δ_M - thickness of coupling wall;

δ - thickness of coupling wall,

heating of the pipe surface is carried out, the surface is leveled with the aid of shape-generating material and a tape is applied with the thickness of glass-coth plastic coupling equal to

$$\delta_M \geq 1.15D\delta / [(\sigma_{bc}/\sigma_b)(D-\delta) - 1.15\delta],$$

where D – external diameter of the pipe;

σ_{bc} - rated ultimate breaking strength of coupling composite material in the annular direction;

σ_b - rated ultimate breaking strength of pipe metal,

the length of the coupling made of glass cloth is equal to

$$L_c\ L_d + 3.12\ (R_\delta)^{1/2},$$

where L_d –length of the defect;

$R_\delta = (D - \delta)/2$ – radius of pipe middle surface,

in this case the tape before winding is impregnated with adhesive compound or is made self-adhesive.

4. A method according to claim 3 **characterized in** that the heating is carried out within the range from 15°C to the maximum value determined by physical-and-mechanical properties of components.

5. A method according to claim 3 **characterized in** that the coupling is applied with preliminary application of quick-setting shape-generating material on the pipe, rolled tape consisting of multilayer glass-composite fabric with threads arranged in longitudinal and transverse directions is wound on the shape-generating material being in consolidated non-deformable state, in this case all tape layers including the place of pipe surface contact with the tape first turn are successively bonded by a continuous layer of adhesive in the course of tape winding which is performed with the tight adjacency of layers with controlled force of tension carried out with the aid of a stretching device with a dynamometer, after this the tape end is loosely positioned with the aid of fixing device, and the coupling is heat-treated until adhesive compound setting and achievement of structural hardness by it.

6. A method according to claim 3 **characterized in** that in the case of cracks or through defects available in the pipe the repair is performed with the use of "cold welding" method.

7. A method according to claim 3 **characterized in** that the rolled tape is manufactured in a "self-adhesive" modification with a layer of adhesive applied preliminarily on one side of the tape.

8. A method according to claim 3 **characterized in** that a high-strength, quick-setting polymer-based material is applied on a defective area (corrosion pits, dents etc.), after its setting excessive layer is removed to the height of 0.5 – 0.8 mm above the pipe surface, then the tape is wound on the pipe, manually or mechanically, with the controlled magnitude of winding, in this case the winding force should not exceed the roll mass, tension control is peformed by dynamometer and calculated according to the following formula:

$$F = F_0 \cdot e^f,$$

where F_0– tension force of tape material near its initial contact with pipe surface;

f - friction coefficient of a bonded subsequent turn of the tape against the surface of a previous turn.

9. A method according to claim 3 **characterized in** that with the aid of shape-generating material the pipe curvature in the area of coupling application is leveled to a level not in excess of 0.5 mm over the length of 300 mm.

Fig. 2

Fig. 3

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(21) 94013653/06 (22) 18.04.94
(46) 10.09.98 Bull. No. 25
(72) Gurov A.E., Gtuntenko G.S.
(71) (73) Gurov Aleksandr Efimovich
(56) JP 1-55714, cl. F 16 L 55/16, 1982.
DE 274865, cl. F 16 L 55/16, 1990.
(54) METHOD AND DEVICE FOR THE REPAIR OF PIPELINES
(57) The invention relates to pipeline transport and can be used for recovering the mechanical strength and tightness of pipelines without stopping their operation. In this case the expansion of the use and reduction of repair periods of underground and surface pipelines is achieved. This is achieved in such a way that when localizing a pipeline leak point and applying a seal on the leak which is strengthened after reducing the pressure in the pipeline, the injured point is localized before the formation of a trunk crack, and the pipeline is strengthened before carrying out the injury sealing. The device is additionally provided with a second seal, both are made in the form of spiral supporting elements wound round the pipeline on both sides from the crack, two beams, each placed between the pipeline and one of the seals, a plunger introduced between the pipeline and beam bosses, elastic gasket connected to the plunger with its one side, and with the other side - contacting the crack zone, and pins linked by their side surfaces with beam bosses through threaded joints, pin first ends – with the plunger, and the second ends have a faceted surface to accept a rotating key. The device has also other distinctive features: 2 pages and 5 claims, 1 figure.

....

the spiral element is made of glass-fiber plastic of predominantly one-direction reinforcement.

The authors are not familiar with any similar engineering solutions that would achieve the set object in the given or close fields of engineering. In this respect the aggregate of the presented distinctive features is regarded significant.

The method and device for repairing pipelines are explained in a diagram given in the drawing.

Shown in the diagram under ref. no. 1 is a pipeline, 2 – pipeline injury in the form of a through crack, 3 – spiral elements on both sides of injury 2, 4 - beams each of which is placed between pipeline 1 and one of spiral elements 3, 5 – plunger introduced between pipeline 1 and the bosses of beam 4, 6 – elastic gasket connected by its one side with plunger 5 and by its other side – contacting the zone of injury 2, and 7 – pins connected by their side surfaces with the bosses of beam 4 through threaded joints and by their first ends - with plunger 5 whose second ends have a faceted surface to accept a rotating key (omitted for clarity).

The method consists in the following.

Injuries 2 are localized in the structural material of pipeline 1 at the stage before the formation of a trunk crack, for example, with the use of methods and means of engineering diagnostic, in particular, by dragging inspection pigs through the pipe (not shown in the diagram) with sensors of acoustic, electromagnetic and other types including those for determining the distance to the defect over the pipeline length. In case of necessity, for example, when transporting toxic (combustible) materials, the pressure of a product in the pipeline is decreased, that partly closes the crack, reduces the probability of system catastrophic failure due to a probable loss of structure bearing capacity in the course of repair and decreases the volume of effluents to the environment during accident elimination. The localized area is released from ground, if necessary, the product transported is pumped out (not shown) and pipeline 1 is strengthened at both sides from injury 2 without carrying out fire operations, for example, by winding supporting spiral elements 3 over the pipe. In this case the strengthening effect will be determined by physical-and-mechanical parameters of material of these elements, by the number of their turns on the pipe, by turn width and thickness. After strengthening pipeline 1 the growth

of the defect over the pipe length in the injury area stops, and the steplike development of the trunk crack becomes impossible due to the stress and strain state conditions of an area under repair. A seal is applied on the defect and, by means of backpressure obtained by a structural way, the leak is stopped and the crack is sealed. Thus the pipeline injury is eliminated promptly.

The device operates in the following way. Outside pipeline 1 two beams 4 are placed before and after injury 2 in such a way that the axis of their longitudinal symmetry would coincide with crack axis or touch the crack, and the distance between the beam bosses turned opposite to one another would comply with the bigger size of plunger 5 which is rectangular in plan. To facilitate the process of installing beams 4 on the steel pipeline they may be manufactured of magnetically hard material, for example, magnetic steel. This also makes it possible to rule out the influence of defect location on the pipe cylindrical surface on convenience and rate of installation work.

When manufacturing beam 4 and plunger 5, they are given (at least on one side) a curvilinear surface with a curvature equal to the curvature of a pipe used in this pipeline which is required by the conditions of device optimum operation. This may be achieved, for example, by metal casting of a beam according to consumable patterns.

The installed beams 4 are fastened to pipeline 1 with the use of highly strong supporting spiral elements 3, for example, manufactured of steel spring tapes which are given mechanical anisotropy by rolling lengthwise, i.e. tensile strength along the tape exceeds a similar indicator across its width, since this makes it possible to decrease tape mass and simplify repair, all other things being equal.

The tapes on the pipe are fixed by glue, adhesive film, or by wood screws (not shown for clarity) if spiral element 3 is manufactured of glass-fiber plastic of predominantly one-direction reinforcement. Such spiral element is more durable as compared with the steel one (since there is no corrosion) and additionally facilitates the work with the device during installation since with one and the same strength it is less in mass (specific strength of structural glass-fiber plastic is higher than that of grade steel). Thus the strengthening of a pipeline is realized to the mechanical seal of a crack and the crack cannot grow further along the pipe.

Spontaneous unwinding of spiral elements 3 is precluded by attributing to them a property of mechanical shape memory during manufacture, since the initial diameter of a self-winding spiral spring tape is selected to be less than the diameter of a pipeline repaired. Therefore, after winding, spiral elements 3 press the pipe body and do not unwind, including unwinding at the expense of friction between turns. For steel pipe this is achieved by hardening the wound semi-finished product, for a tape of glass-fiber plastic – by setting the prepreg wound on a mandrel, for example, under the action of high temperature. Thickness of tapes is 0.5 to 2.0 mm.

Length of a beam – size according to pipeline generatrix, is selected to be within 0.2 to 0.4 of its diameter and should be equal or somewhat exceed the width of spiral element tape.

Plunger 5 fastened at least at one side with elastic gasket 6, for example, by way of bonding or mechanically at two sides, for example, a gasket in the form of elastic tube is slipped over the plunger working portion, inserted (introduced) between pipeline 1 and beam bosses in such a way, that the elastic gasket would cover the crack zone. Plunger length is selected to be no more than one-and-a-half length of the trunk crack size for a corresponding pipeline. The use of non-combustible and corrosion-resistant rubbers, polyvinylchloride, and also polyurethane compounds is possible for the material of gasket 6. The thickness of the material is selected to be sufficient for ensuring functions required of the gasket.

After conducting the operation of plunger 5 introduction its position relative to the crack zone is specified by the coincidence of threaded holes in the bosses of beam 4 with cylindrical necks in the plunger itself. Its accurate fixation in an established position is achieved by one-sided extension of the bosses to one of the remote beam surfaces across plunger movement. This impedes plunger fallout from the accurate position during its introduction.

After that pins 7 are inserted into threaded holes of the bosses of beam 4 and, while rotating the pins with a key from one end, plunger 5 is moved closer to pipeline 1 by the action of pins 7 opposite ends. In so doing the injury is sealed reliably and pressurized with elastic gasket 6 in the crack zone at the expense of plunger 5 backpressure organized mechanically according to the device design. The force of elastic gasket compression can in case of necessity be determined and calculated for a certain case. The diameter of steel pins is selected proceeding from the conditions of their strength and stability.

For pipelines of large diameters beams 4 and plunger 5 are fitted with stiffening ribs and this decreases the device mass additionally and, as was noted above, facilitates the work with it (not shown for clarity).

The proposed process of repair provides for a fast prevention and elimination of failures in important pipelines. The prevention is realized with the use of operations of a method, when conducting repair of non-through cracks, elimination of failures – during the repair of through cracks of a pipeline. The process is rather efficient, when communication with a controller is lost or, for other technical reasons, quick emergency release of the pressure of a product being transported through the pipeline is impossible or undesirable, i.e. when the product features hazardous properties. In such cases attending personnel may have individual means of protection: fire-fighting equipment, gas masks, etc.

It looks apparent that a team of two persons regardless of the time required for digging in the point of pipeline damage, is capable of implementing the repair for a period of 30 to 40 minutes. The duration of repair depends mostly on pipeline diameter.

The engineering solution may also be used in underwater pipelines providing sufficient illumination in the course of repair work implementation by divers.

The process can be used in metal and non-metal pipes.

Economic effect from the use of the invention is achieved in three directions as follows.

Firstly, at the expense of a possibility to repair pipelines at an earlier stage of structural material damage which ensures a bigger resource of transporting valuable products of oil, gas and chemical industry, accordingly, their less irreversible loss for consumers, less environment pollution, less expenses for penal sanctions.

Secondly, due to a higher rate of repair, not only in comparison with the prototype, since a damage is detected at an earlier stage, therefore, it is less in size and, accordingly, requires a shorter period for repair, but also in comparison with the traditional process that makes use of pipe welding, because the proposal contains less process operations and less scope of work to be implemented. This relates, for example, to excavation work at breaking up the ground in a pipeline section under repair.

Thirdly, the cost of the device at large-scale manufacture should be approximately 5 to 6 times as little as compared with a new welded-in pipe, for instance, a imported longitudinal welded tube of steel manufactured by the converter process and having 426 mm in diameter and 11.5 m in length costs about 730 to 740 US dollars.

CLAIMS

1. A method of repairing pipelines consisting in that the leak point of a pipeline is localized and a seal is applied on the leak which is strengthened after pressure reduction in the pipeline, **characterized in** that the damage point is localized before the development of a trunk crack, and the pipeline is strengthened before sealing the damage.

2. Device according to claim 1 containing a seal **characterized in** that the seal is fitted with the second seal, both of them are manufactured in the form of supporting spiral elements that are wound on at both sides of the crack, two beams, each of which is placed between the pipeline and one of the seals, a plunger introduced between the pipeline and beam bosses, elastic gasket fastened by its one side with the plunger, and with its second side contacting the crack zone, and pins which by their side surface are linked by means of threaded joints with beam

bosses, their first ends – with the plunger, and their second ends have a faceted surface to accept a rotating key.

3. Device according to claim 2 **characterized in** that the beams and plunger feature a profiled surface whose curvature is equal to the curvature of the pipeline.

4. Device according to claims 2 and 3 **characterized in** that the plunger is manufactured in the form of a plate rectangular in plan, whose thickness is comparable with or exceeds the thickness of the pipeline wall in the vicinity of short sides of which, on a free surface, there are cylindrical necks with a diameter more than and the depth equal to or less than the pins diameter.

5. Device according to claims 2 to 4 **characterized in** that the beams are made of magnetized material, for instance, of magnetic steel.

6. Device according to claims 2 to 5 **characterized in** that mechanical anisotropy is attributed to the spiral element over its length, for instance, by the process rolling of steel tape.

7. Device according to claims 2 to 6 **characterized in** that the spiral element is made mostly of glass-fiber plastic of predominantly one-direction reinforcement.